

Senecio vulgaris L. (Asteraceae)
Common Groundsel

Description. Annual, herbaceous, from a thin, branched taproot; stems 8-60 cm tall, erect to decumbent, somewhat succulent, sparsely tomentose when young, glabrous to sparsely villous, simple or branched near the base. Leaves 2-5(10) cm long, 0.5-4.5 cm wide, deeply pinnately lobed or toothed, glabrous to sparsely villous, the lobes oblong, irregularly toothed, the lower ones petioled, oblanceolate to obovate, base abruptly tapered, the upper ones oblong, sessile or clasping, the bases sometimes auriculate. Heads discoid (all corollas radial and salverform), 5-10 mm long, 4-10 mm wide, cylindrical to subcylindrical, subsessile to stalked, 8-20, in terminal or axillary clusters. Phyllaries in two series, glabrous to sparsely pubescent, green, black-tipped, the outer ones 2-10, 1-2 mm long, the inner ones 21, 4-6 mm long, linear-lanceolate, margins scarious, apices acute, glabrous to loosely tomentose. Corollas yellow. Achenes 1.5-2 mm long, brown, glabrous or with appressed-puberulent ribs; pappus 15-20 mm long, simple, white. In California, flowering from January through December. (Barkley 1993, Chater and Walters 1976, Clapham et al. 1962, Cronquist 1980, 1994, Fernald 1950, Great Plains Flora Association 1986, Munz 1959, Welsh et al. 1987).

Senecio vulgaris is a polyploid ($2n=40$), believed to have been derived through hybridization involving at least one extant species, *S. squalidus* L. (Ashton and Abbott 1992, Harris 1992, Stace 1977). Introgressive hybridization from *S. squalidus* has contributed to genetic variability in European populations (Abbott et al. 1992), including forms with ray flowers (Abbott et al. 1990, Ingram and Noltie 1984, Ingram et al. 1980). Such races are not apparently present in introduced populations, at least in California as inferred from descriptions in Barkley (1993) and Munz (1959). Naturalized British populations show considerable genetic variation (Theaker and Briggs 1992, 1993). Genetic variation included the evolution of strains with varying growth rates, this in response to natural selection imposed by weed removal methods (Kadereit and Briggs 1985, Theaker and Briggs 1993).

Geographic distribution. Native and widespread throughout continental Europe, but more common in the Mediterranean region. It has been introduced into Australia, New Zealand, throughout North America, Great Britain [repeatedly according to Stace (1997) and Ingram et al. 1980], Japan, southern Africa (Arnold and de Wet 1993, Chater and Walters 1976, Clapham et al. 1962, Cronquist 1980, 1994, Fernald 1950, Ohwi 1953, Webb et al. 1988).

Common groundsel was first reported from California ("near San Francisco") in 1876 (Brewer et al. 1876). Naturalized populations occur on all the Channel Islands except for Santa Barbara (Junak et al. 1995), coastal California from Del Norte County southward to San Diego County, and in most counties west of the Sierra Nevada (Anonymous 1998, Barkley 1993).

Ecological distribution. In its natural range, common groundsel occurs in cultivated and fallow fields (Chater and Walters 1976, Clapham et al. 1962). It has been reported elsewhere from similar habitats (e.g., (Barkley 1993, Fernald 1950, Munz 1959, Welsh et al. 1987), in turf (Murphy 1996), and in household gardens (Senesac 1991).

Reproductive and vegetative biology. Common groundsel is self-compatible, but experiences some outcrossing in native populations (Abbott et al. 1990, Marshall and Abbott 1984a, 1984b). Reproductive capacity is high relative to total plant biomass (Harper and Ogden 1970). Small, light seeds and proportionately large pappus confer a relatively high level of dispersability (Anderson 1992, Sheldon and Burrows 1973)

In Britain, common groundsel seeds may germinate at any time of the year, depending on availability of water (Harper and Ogden 1970). Most plants live for about 3 months; flowering and reproduction begins within 6-8 weeks. A comparison of strains from wild Scottish and Spanish populations demonstrated differences in the proportion of dormant seeds and rates of germination, which were related to differences between cold- and warm-temperate (Mediterranean) climates (Ren and Abbott 1991). In general, seeds of cold-temperate strains do not germinate unless they have been exposed to freezing temperatures; those of warm-temperate (Mediterranean) climates display little dormancy, germinating only after sufficient precipitation. However, buried seeds may remain viable and dormant for as long as 5 years (Roberts 1964).

Using experimental populations differing in patchiness and density, Bergelson (1990) demonstrated that establishment and reproductive capacity was greater when competing species (i.e., *Poa annua*) were clumped rather than randomly distributed; this suggests that common groundsel may not be competitive under conditions of relatively dense cover (Bergelson et al. 1993). This is consistent with observations that common groundsel is invasive and common in disturbed habitats (Harper and Ogden 1970, Murphy 1996, Senesac 1991), and does not compete well under horticultural practices that minimize open space (Qasem and Hill 1993). Common groundsel also has been reported as invasive after fires, both in European shrubland (Trabaud 1991) and in California chasparal (Sweeney 1956, Biswell 1974). However, in both instances, it does not persist except in disturbed sites.

Allelopathy (Qasem and Hill 1989), nitrogen levels (Qasem and Hill 1993), and both intra- and inter-specific interactions among seedlings (Bergelson and Perry 1989) have been implicated as factors conferring competitive advantage to persistence in naturalized populations.

Weed status. Common groundsel is not considered a serious noxious weed in agricultural or horticultural practice, at least at a global level (not listed by Holm et al. 1977), nor is it considered a noxious weed by the State Dept. of Food and Agriculture (Anonymous 1996). However, it has been reported as weedy and invasive, primarily in disturbed sites, fallow or cultivated (both agricultural and horticultural) fields, in turf, and in urban gardens, where it is able to germinate and grow at any time the year (Murphy 1996, Senesac 1991).

Microbial pathogens. Several studies have investigated natural fungal pathogens (Ayres 1995, Baka and Losel 1992, Hallett et al. 1990a, 1990b, Hallett and Ayres 1992, Harry and Clarke 1992, Paul 1989, Paul and Ayers 1987b, 1990, Preese 1987), which include mildews (*Albugo* spp., *Botrytis* spp., *Erysiphe fischeri*, *E. cichoracearum*, *Sphaerotheca epilobii*) and rusts (*Puccinia lagenophorae*, *P. punctiformis*, *Uromyces* spp.). Most of these studies, however, are based on greenhouse conditions or in horticultural (e.g., flowers) and agricultural production (e.g., lettuce).

Application of fungal diseases to biocontrol of *Senecio vulgaris* has been discussed by Paul et al. (1993). Damage by *Puccinia lagenophorae* is enhanced by mild drought conditions, periods of frost in winter, and by competition between groundsel and neighbouring plants, but is reduced

by nutrient deficiency. Rust injury also is greatly increased by secondary infection of pustules by necrotrophic fungi. Other interactions that influence survival include the extent of mycorrhizal infection and phosphate levels in the soil (West 1995a, West 1995b), availability and composition of nutrients (Paul and Ayres 1986a, Paul and Ayres 1990), season of infestation (Paul and Ayres 1986c, Paul and Ayres 1986d, Paul and Ayres 1986e, Paul and Ayres 1987a), and intra- or inter-specific competition (Paul and Ayres 1986b, Paul and Ayres 1987b, Paul and Ayres 1990). A few studies have shown that *Senecio vulgaris* can evolve fungal-resistant strains (Harry and Clarke 1986, 1987).

Insect pathogens. No literature that reported common groundsel as a host of insect pathogens was found. Common groundsel produces pyrrolizidine alkaloids (e.g., Hartmann and M. Zimmer, 1986. Pieters and Vlietinck 1988), which are known to be either toxic (McHenry et al. 1990, Mitich 1995) or distasteful (Blaney and Simmonds 1985) to potential herbivores.

Herbicide control. The effectiveness of over 10 different herbicides (e.g., metolachlor, acifluorfen, simazine) on groundsel were tested (Al-Khatib 1995, Gallitano and Skroch 1993, Sym 1988), but primarily in association with agricultural crops or container propagation. Several studies studied various levels of resistance to such herbicides as atrazine, simazine, and triazine (Delaney 1984, Derr 1991, Fuerst et al. 1986, Havaux 1989, McCloskey and Holt 1990, 1991, Stephenson et al. 1990, Watson et al. 1987). Watson et al. (1987) provided evidence for relatively simple inheritance (a few loci) for herbicide resistance. Stowe and Holt (1988) examined physiological mechanisms that confer herbicide resistance by comparing triazine-resistant, non-resistant, and hybrid strains. Holt and Goffner (1985) studied morphological and physiological traits associated with simazine resistance.

Relatively rapid selection for genetic strains differing in cultural conditions, minor morphological traits, and herbicide resistance has been demonstrated in some populations (Briggs and Block 1992, Briggs et al. 1992, Radosevich 1973). Holliday and Putwain (1977, 1980) showed that recruitment of simazine-resistant strains came from resident seed banks, rather than from immigration seeds, because resident strains germinated, survived, and reproduced during times coincident with low herbicide levels.

Literature Cited

- Abbott, R., J. Irwin, and F. Forbes. 1990. Absence of a radiate morph bearing self-incompatible ray florets from Edinburgh populations of *Senecio vulgaris* L.
Heredity. 64: 391-393.
- Abbott, R., P. Ashton, and D. Forbes. 1992. Introgressive origin of the radiate groundsel, *Senecio vulgaris* L. var. *hibernicus* Syme: Aat-3 evidence. Heredity. 68: 425-435.
- Al-Khatib, K. 1995. Broadleaf weed control with clomazone in pickling cucumber (*Cucumis sativus*). Weed Technology. 9: 166-172.
- Anderson, M. 1992. An analysis of variability in seed settling velocities of several wind-dispersed Asteraceae. American Journal of Botany. 79: 1087-1091.
- Anonymous. 1996. Exotic pest plants of greatest ecological concern in California as of August 1996. California Exotic Pest Plant Council. 8 pp.

- Anonymous. 1998. California county flora database version 2, Santa Barbara Botanic Garden and USDA National Plants Data Center, Santa Barbara and New Orleans. URL = plants.usda.gov
- Arnold, T. and B. de Wet. 1995. Plants of southern Africa: names and distribution. National Botanical Institute, Pretoria, South Africa. 825 pp.
- Ashton, P. and R. Abbott. 1992. Isozyme evidence and the origin of *Senecio vulgaris* (Compositae). Plant Systematics and Evolution. 179: 167-174.
- Ayres, P. 1995. Water and solutes in host: pathogen relations. Aspects of Applied Biology 45: 161-167.
- Baka, Z. and D. Losel. 1992. Infection of vascular tissues by the autoecious rusts *Puccinia punctiformis* and *Puccinia lagenophorae*: a cytological study. Physiological and Molecular Plant Pathology. 40: 411-421.
- Barkley, T. 1986. Asteraceae. pp. 838-1031. In Great Plains Flora Association. 1986. Flora of the Great Plains. University of Kansas, Lawrence. 1392 pp.
- Barkley, T. 1993. *Senecio*. pp. 336-342. In Hickman, J. (ed.). The Jepson Manual: higher plants of California. University of California Press, Berkeley. 1400 pp.
- Bergelson, J. 1990. Spatial patterning in plants: opposing effects of herbivory and competition. Journal of Ecology. 78: 937-948.
- Bergelson, J. and R. Perry. 1989. Interspecific competition between seeds: relative planting date and density affect seedling emergence. Ecology 70: 1639-1644.
- Bergelson, J., J. Newman, and E. Floresroux. 1993. Rates of weed spread in spatially heterogeneous environments. Ecology. 74: 999-1011.
- Biswell, H. 1974. Effects of fire on chaparral. pp. 321-364. In Kozlowski, T. and C. Ahlgren (eds.). Fire and Ecosystems. Academic Press, New York.
- Blaney, W. and M. Simmonds. 1985. Food selection by locusts: the role of learning in rejection behaviour. Entomologia Experimentalis et Applicata. 39: 273-278.
- Brewer, W., S. Watson, and A. Gray. 1876. Botany of California. Volume 1. University Press, Cambridge, Massachusetts. 628 pp.
- Briggs, D. and M. Block. 1992. Genecological studies of groundsel (*Senecio vulgaris* L.). I. Maintenance of population variation in the Cambridge University Botanic Garden. The New Phytologist. 121: 257-266.
- Briggs, D., M. Block, E. Fulton, and S. Vinson. 1992. Genecological studies of groundsel (*Senecio vulgaris* L.). II. Historical evidence for weed control and gene flow in the Cambridge University Botanic Garden. The New Phytologist. 121: 267-279.
- Chater, A. and S. Walters. 1976. *Senecio*. pp. 191-205. In Tutin et al. (eds). Flora Europaea. Plantaginaceae to Compositae. Cambridge University Press, Cambridge. 505 pp.
- Clapham, A., T. Tutin, and E. Warburg. 1962. Flora of the British Isles. Cambridge University Press, Cambridge. 1269 pp.
- Cronquist, A. 1980. Vascular flora of the southeastern United States. Volume 1. Asteraceae. University of North Carolina Press, Chapel Hill. 261 pp.
- Cronquist, A. 1994. Asterales. In Cronquist et al. (eds.) Intermountain Flora. Volume 5: 1-496.
- Delaney, H. 1984. Evaluation of herbicides for the control of simazine--resistant *Senecio vulgaris* L. Aspects of Applied Biology. 12: 385-390.
- Derr, J. 1991. Tolerance of woody nursery stock to classic (chlorimuron) and harmony (thiameturon). Journal of Environmental Horticulture. 9: 9-13.

- Fernald, M. 1950. Gray's Manual of Botany. Eighth Edition. American Book Company, New York. 1632 pp.
- Fuerst, E., C. Arntzen, K. Pfister, and D. Penner. 1986. Herbicide cross-resistance in triazine-resistant biotypes of four species. *Weed Science*. 34: 344-353.
- Gallitano, L. and W. Skroch. 1993. Herbicide efficacy for production of container ornamentals. *Weed Technology* 7:103-111.
- Hallett, S. and P. Ayres. 1992. Invasion of rust (*Puccinia lagenophorae*) aecia on groundsel (*Senecio vulgaris*) by secondary pathogens: death of the host. *Mycological Research*. 1992. 96 : 142-144.
- Hallett, S., N. Paul, and P. Ayres. 1990a. Botrytis cinerea kills groundsel (*Senecio vulgaris*) infected by rust (*Puccinia lagenophorae*). *The New Phytologist*. 114: 105-109.
- Hallett, S., N. Paul, and P. Ayres. 1990b. Conidial germination of Botrytis cinerea in relation to aeciospores and aecia of groundsel rust (*Puccinia lagenophorae*). *Mycological Research*. 94: 603-606.
- Harris, S. 1992. Molecular systematics of the genus *Senecio* L. II. The origin of *S. vulgaris* L. *Heredity*. 69: 112-121.
- Harper, J. and J. Ogden. 1970. The reproductive strategy of higher plants. The concept of strategy with special reference to *Senecio vulgaris* L.. *Journal of Ecology* 58: 681-698.
- Harry, I. and D. Clarke 1986. Race-specific resistance in groundsel (*Senecio vulgaris*) to the powdery mildew *Erysiphe fischeri*. *The New Phytologist*. 1986. 103: 167-175.
- Harry, I. and D. Clarke. 1987. The genetics of race-specific resistance in groundsel (*Senecio vulgaris* L.) to the powdery mildew fungus, *Erysiphe fischeri* Blumer. *The New Phytologist*. 107: 715-723.
- Harry, I. and D. Clarke. 1992. The effects of powdery mildew (*Erysiphe fischeri*) infection on the development and function of leaf tissue by *Senecio vulgaris*. *Physiological and Molecular Plant Pathology*. 40: 211-224.
- Hartmann, T. and M. Zimmer. 1986. Organ-specific distribution and accumulation of pyrrolizidine alkaloids during the life history of two annual *Senecio* species. *Journal of Plant Physiology*. 122: 67-80.
- Havaux, M. 1989. Comparison of atrazine-resistant and -susceptible biotypes of *Senecio vulgaris* L.: Effects of high and low temperatures on the in vivo photosynthetic electron transfer in intact leaves. *Journal of Experimental Botany*. 1989. 40: 849-854.
- Holliday R. and P. Putwain. 1977. Evolution of resistance to simazine in *Senecio vulgaris* L. *Weed Research* 17: 291-296.
- Holliday R. and P. Putwain. 1980. Evolution of herbicide resistance in *Senecio vulgaris*: variation in susceptibility to simazine between and within populations. *Journal of Applied Ecology*. 17: 779-791.
- Holm, L., D. Plucknett, J. Pancho, and J. Herberger. 1977. The world's worst weeds: distribution and ecology. University Press of Hawaii, Honolulu. 609 pp.
- Holt, J. and D. Goffner. 1985. Altered leaf structure and function in Triazine-resistance common groundsel (*Senecio vulgaris*). *Plant Physiology*. 79: 699-705.
- Ingram, R. and H. Noltie. 1984. Ray floret morphology and the origin of variability in *Senecio cambrensis* Rosser: a recently established allopolyploid species. *New Phytologist*. 96: 601-607.

- Ingram, R., J. Weir, and R. Abbott. 1980. New evidence concerning the origin of inland radiate groundsel, *Senecio vulgaris* L. var. *hibernicus* Syme. New Phytologist 84: 543-546.
- Junak, S., T. Ayers, R. Scott, D. Wilken, and D. Young. 1995. A flora of Santa Cruz Island. Santa Barbara Botanic Garden and California Native Plant Society, Santa Barbara and Sacramento. 397 pp.
- Kaderet, J. and D. Briggs. 1985. Speed of development of radiate and non-radiate plants of *Senecio vulgaris* L. from habitats subject to different degrees of weeding pressure. New Phytologist 99: 155-169.
- Lorenzi, H. and L. Jeffery. 1987. Weeds of the United States and their control. Van Nostrand Company, New York. 355 pp.
- Marshall, D. and R. Abbott. 1984a. Polymorphism for outcrossing frequency at the ray floret locus in *Senecio vulgaris*. II. Confirmation. Heredity 52: 331-336.
- Marshall, D. and R. Abbott. 1984b. Polymorphism for outcrossing frequency at the ray floret locus in *Senecio vulgaris*. III. Causes. Heredity 52: 331-336.
- McCloskey, W. and J. Holt. 1990. Triazine resistance in *Senecio vulgaris* parental and nearly isonuclear backcrossed biotypes is correlated with reduced productivity. Plant Physiology. 92: 954-962.
- McCloskey, W. and J. Holt. 1991. Effect of growth temperature on biomass production of nearly isonuclear triazine-resistant and -susceptible common groundsel (*Senecio vulgaris* L.). Plant, Cell and Environment. 14: 699-705.
- McHenry, W., R. Bushnell, M. Oliver, and R. Norris. 1990. Three poisonous plants common in pastures and hay: fiddleneck, common groundsel, yellow starthistle. Leaflet 21483, University of California, Cooperative Extension Service. 10 pp.
- Munz, P. 1959. A flora of California. University of California Press, Berkeley. 1681 pp.
- Murphy, T. 1996. Herbicide-resistant weeds in turfgrasses. Turf Grass Trends. January 1996: 7-10.
- Mitich, L. 1995. Common groundsel (*Senecio vulgaris*). Weed Technology 9: 209-211.
- Paul, N. 1989. The effects of *Puccinia lagenophorae* on *Senecio vulgaris* in competition with *Euphorbia peplus*. Journal of ecology. 77: 552-564.
- Ohwi, J. 1953. Flora of Japan. National Science Museum, Tokyo. 1067 pp.
- Paul, N. and P. Ayres. 1986a. The effects of infection by rust (*Puccinia lagenophorae* Cooke) on the growth of groundsel (*Senecio vulgaris* L.) cultivated under a range of nutrient concentrations. Annals of Botany. 58: 321-331.
- Paul, N. and P. Ayres. 1986b. Interference between healthy and rusted groundsel (*Senecio vulgaris* L.) within mixed populations of different densities and proportions. The New Phytologist. 104: 257-269.
- Paul, N. and P. Ayres. 1986c. The impact of a pathogen (*Puccinia lagenophorae*) on populations of groundsel (*Senecio vulgaris*) overwintering in the field. I. Mortality, vegetative growth and the development of size hierarchies. Journal of Ecology. 74: 1069-1084.
- Paul, N. and P. Ayres. 1986d. The impact of a pathogen (*Puccinia lagenophorae*) on populations of groundsel (*Senecio vulgaris*) overwintering in the field. II. Reproduction. Journal of Ecology. 74: 1085-1094.
- Paul, N. and P. Ayres. 1986e. Seasonal effects on rust disease (*Puccinia lagenophorae*) of *Senecio vulgaris*. Symbiosis. 2: 165-173.

- Paul, N. and P. Ayres. 1987a. Survival, growth and reproduction of groundsel (*Senecio vulgaris*) infected by rust (*Puccinia lagenophorae*) in the field during summer. *Journal of Ecology*. 75: 61-71.
- Paul, N. and P. Ayres. 1987b. Effects of rust infection of *Senecio vulgaris* on competition with lettuce. *Weed Research*. 27: 431-441.
- Paul, N. and P. Ayers. 1990. Effects of interactions between nutrient supply and rust infection of *Senecio vulgaris* L. on competition with *Capsella bursa-pastoris* (L.) Medic. *The New Phytologist*. 114: 667-674.
- Paul, N., P. Ayres, and S. Hallett. 1993. Mycoherbicides and other biocontrol agents for *Senecio* spp. *Pesticide Science* 37: 323-329.
- Pieters, L. and A. Vlietinck. 1988. Spartioidine and usaramine, two pyrrolizidine alkaloids from *Senecio vulgaris*. *Planta Medica*. 54: 178-179.
- Preece, T. 1987. *Albugo* on *Senecio vulgaris*. *The Mycologist*. 21:71.
- Qasem, J.R and T. Hill. 1993. Effects of the form of nitrogen on the growth and nutrient uptake of tomato, groundsel and fat-hen. *The Journal of Horticultural Science*. 68: 161-170.
- Qasem, J. and T. Hill. 1989. Possible role of allelopathy in the competition between tomato, *Senecio vulgaris* L. and *Chenopodium album* L. *Weed Research*. 29: 349-356.
- Qasem, J. and T. Hill. 1993. A comparison of the competitive effects and nutrient accumulation of fat-hen and groundsel. *Journal of Plant Nutrition*. 16: 679-698.
- Radosevich, S. 1973. Differential sensitivity of two common groundsel biotypes (*Senecio vulgaris* L.) to several s-triazine herbicides. Ph.D. dissertation, Oregon State University, Corvallis. 123 pp.
- Ren, Z. and R. Abbott. 1991. Seed dormancy in Mediterranean *Senecio vulgaris* L. *The New Phytologist*. 117: 673-678.
- Roberts, H. 1964. Emergence and longevity in cultivated soil of seeds of some annual weeds. *Weed Research* 4: 296-307.
- Senesac, A. 1991. Common groundsel *Senecio vulgaris* L. *Long Island Horticulture News*. June 1991, pp. 2-3.
- Sheldon, J. and F. Burrows. 1973. The dispersal effectiveness of the achenepappus units of selected Compositae in steady winds with convection. *New Phytologist* 72: 665-675.
- Stace, C. 1977. The origin of radiate *Senecio vulgaris* L. *Heredity* 39: 383-388.
- Stephenson, G., M. Dykstra, R. McLaren, and A. Hamill. 1990. Agronomic practices influencing triazine-resistant weed distribution in Ontario. *Weed Technology* 4: 199-207.
- Stowe, A. and J. Holt. 1988. Comparison of triazine-resistant and -susceptible biotypes of *Senecio vulgaris* and their F1 hybrids. *Plant Physiology*. 87: 183-189.
- Sweeney, J. 1956. Responses of vegetation to fire. A study of the herbaceous vegetation following chaparral fires. *University of California Publications in Botany*. 28: 143-250.
- Sym, R. 1988. Herbicide use in large British nurseries : problems and perspectives. *Aspects of Applied Biology*. 16: 249-255.
- Theaker, A. and D. Briggs. 1992. Genecological studies of groundsel (*Senecio vulgaris* L.). III. Population variation and its maintenance in the University Botanic Garden, Cambridge. *The New Phytologist*. 121: 281-291.
- Theaker, A. and D. Briggs. 1993. Genecological studies of groundsel (*Senecio vulgaris* L.). IV. Rate of development in plants from different habitat types. *The New Phytologist*. 123: 185-194.

- Trabaud, L. 1991. Is fire an agent favouring plant invasions? pp. 179-190. In Groves, R. and F. Di Castri. (eds.) Biogeography of Mediterranean Invasions. Cambridge University Press, Cambridge. 485 pp.
- Watson, D., A. Mortimer, and P. Putwain. 1987. The seed bank dynamics of triazine resistant and susceptible biotypes of *Senecio vulgaris*--implications for control strategies. Proceedings of the British Crop Protection Conference-Weeds. 3: 917- 924.
- Webb, C., W. Sykes, and P. Garnock-Jones. 1988. Flora of New Zealand. Volume 4. Naturalized pteridophytes, gymnosperms, dicotyledons. Department of Scientific and Industrial Research, Christchurch. 1365 pp.
- Welsh, S., N. Atwood, S. Goodrich, and L. Higgins (eds.). 1987. A Utah flora. Great Basin Naturalist Memoirs 9: 1-894.
- West, H. 1995a. Interactions between arbuscular mycorrhizas and biotrophic foliar pathogens: physiological consequences for the host. Aspects of Applied Biology 42: 185-193.
- West, H. 1995b. Soil phosphate status modifies response of mycorrhizal and non-mycorrhizal *Senecio vulgaris* L. to infection by the rust, *Puccinia lagenophorae* Cooke. The New Phytologist. 129: 107-116.